

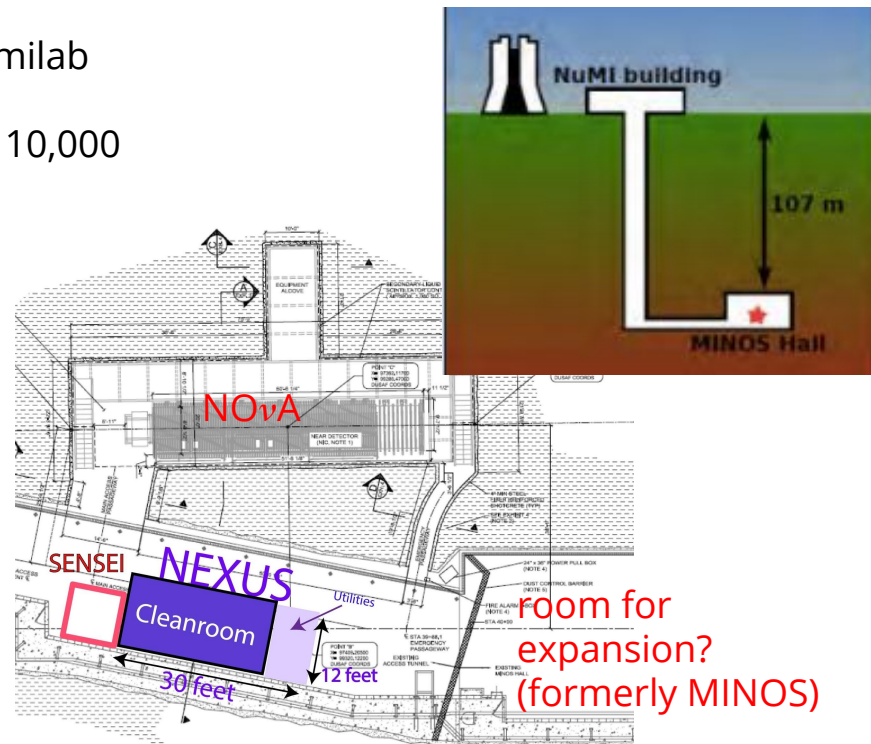
NEXUS@FNAL Status and Plans

Nick Mast



NEXUS@FNAL Infrastructure

- Northwestern EXperimental Underground Site at Fermilab (**NEXUS@FNAL**)
- Underground cryogenic device testing facility in class 10,000 clean room
- Vibration-isolated dry dilution refrigerator
 - Temperatures down to **8 mK**
- 107 m depth (300 meters water equivalent) + lead shielding (in progress)
 - Expected background <100 events/keV/kg/day
- Optical fiber, n, γ cal. sources
 - Exploring <1 keV options
- **Reconfigurable** for different payloads

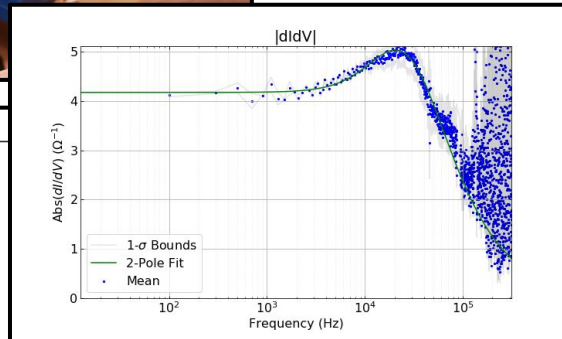
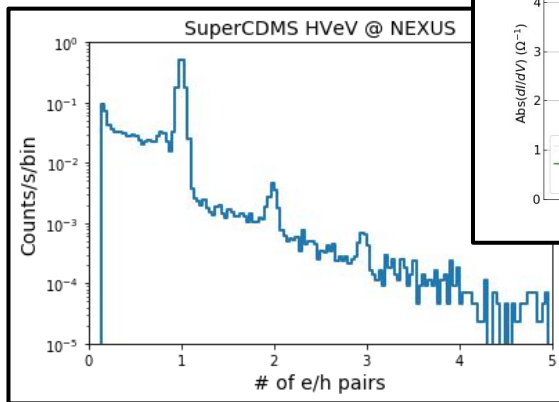
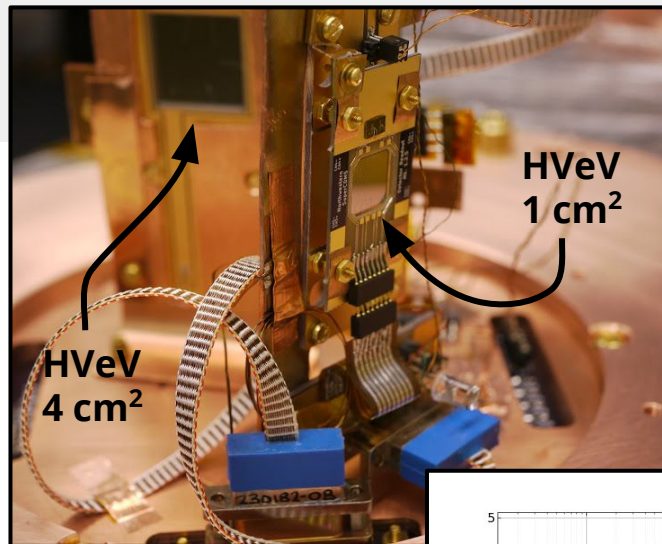


Z. Hong, et al. "NEXUS@FNAL", [Poster, LTD-18](#)

SuperCDMS R&D

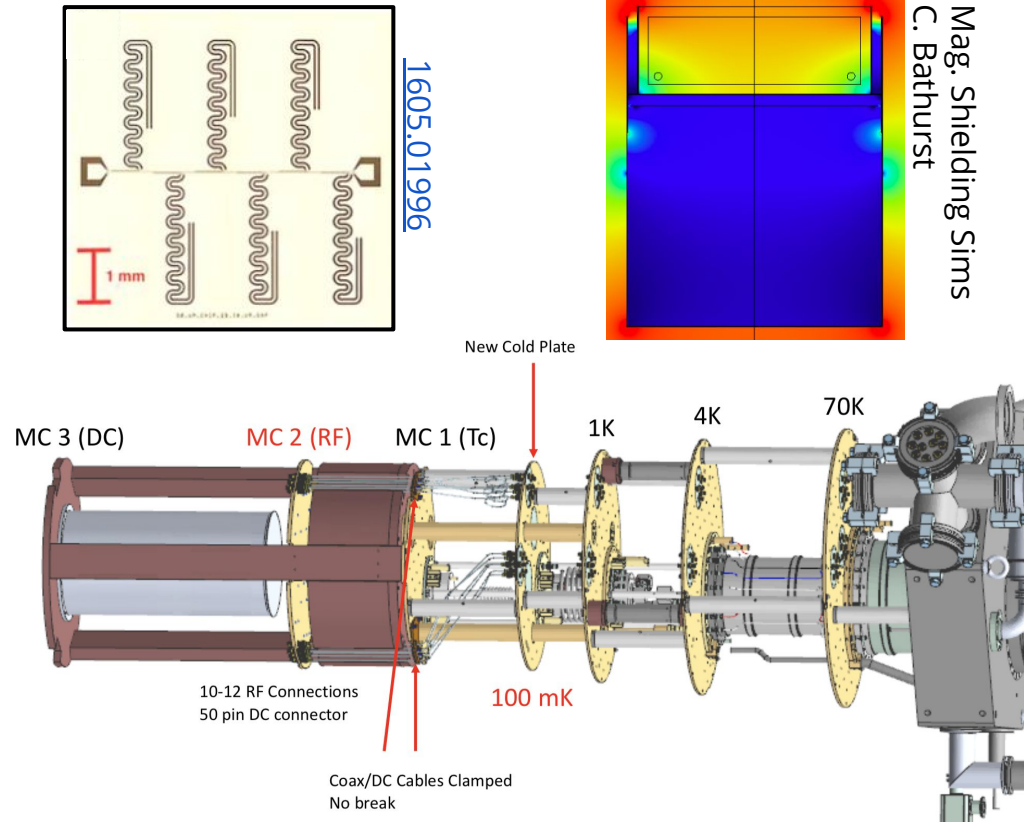


- Currently testing new generations of small ($\sim 1\text{g}$) “HVeV” devices with **single e/h pair resolution**
- Improving superconducting Transition Edge Sensor (TES) design
 - Complex impedance measurements (N. Mishra and R. Chen)
- Studying detector leakage currents when biased with $\sim 100\text{ V}$ to inform operation of larger devices at SNOLAB
- Investigating low energy excesses ([2002.06937](#))
- Good platform for **low mass ($<1\text{ GeV}/c^2$) DM searches**
 - Exposure comparable to recent HVeV DM searches ([2005.14067](#)) in far less time



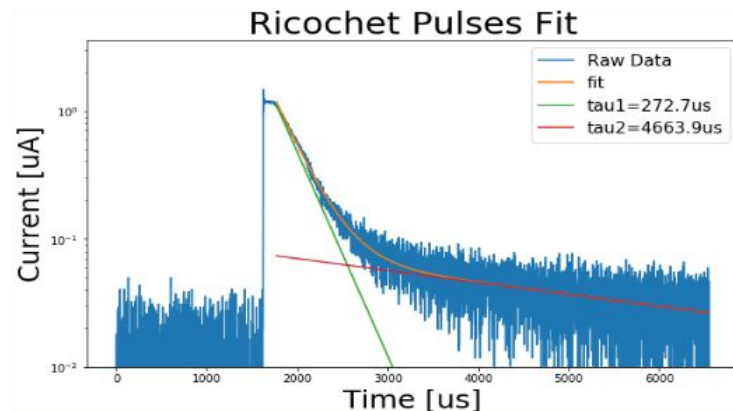
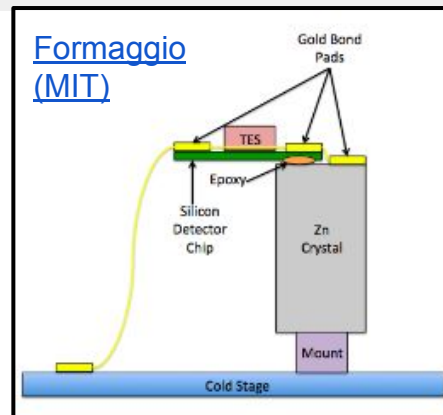
Quantum Information Science (QIS)

- Collaboration with R. McDermott (UW-Madison), D. Bowring (FNAL), et al.
 - Study Quasiparticle Poisoning in **Superconducting Microwave Resonators** ([1610.09351](#))
- Quantum coherence improved underground ([2005.02286](#))
- Will use NEXUS to study coherence time in **low background environments**
- Fridge upgrades (2020 FNAL LDRD, Bowring DOE ECA)
 - Superconducting coax wiring for RF signals
 - Additional MC plate
 - Magnetic shielding (@ 1K stage)
 - Improved light and EMI shielding
 - Vibration reduction



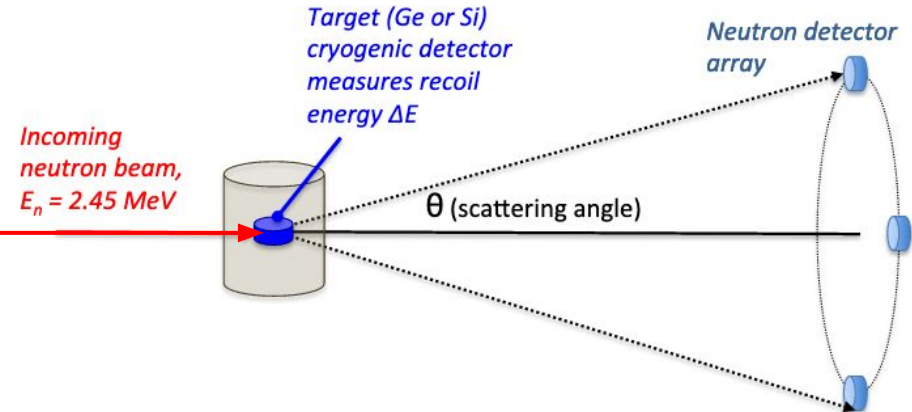
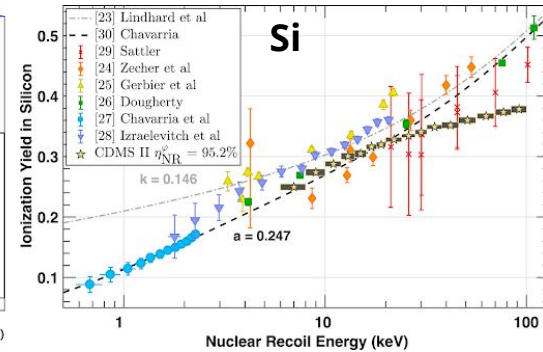
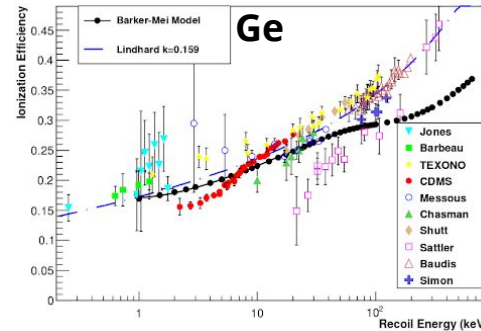
Ricochet R&D

- Ricochet Collaboration will measure Coherent Elastic Neutrino Nucleus Scattering (**CEvNS**) at nuclear reactor ([1107.3512](#), [1612.09035](#))
- Need to measure ~ 100 eV recoil energy
- One possibility: Zn target with Ir/Pt TES
 - **ER/NR discrimination** via pulse shape (different QP/phonon lifetimes)
- **Ir/Pt TES chip** running in NEXUS
 - Pulse shapes experimentally understood (R. Chen, et al., [Neutrino 2020, #587](#))



Ionization Yield with Neutron Scattering

- **IMPACT** (Ionization Measurement with Phonons At Cryogenic Temperatures)
 - Ionization yield measurement at **low recoil energy (≥ 100 eV)**
 - Elastic scattering of neutrons off detector nuclei as **proxy for DM interactions**
- Will use SuperCDMS Si and Ge devices
- 2.45 MeV neutron beam from commercial DD generator
- Backing array of neutron detectors for scattering angle (energy)



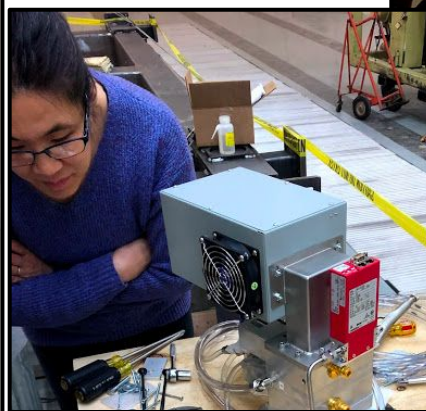
Conclusion

- NEXUS is a new clean, low-background, versatile cryogenic facility
- Fruitful **SuperCDMS** and **Ricochet** R&D in progress
- Upcoming **QIS** upgrades and studies
- n-generator (in hand) and backing array in near future for **neutron-scattering**
- Many projects in the pipeline not mentioned here
 - UV, Vis, BB IR sources
 - KIDs (Golwala @ Caltech)
 - meV-gap Photodetectors (Y. Kahn @UIUC)
 - 4K integrated charge amps (FNAL ASIC, Fahim ECA)

(Some) Current NEXUS Folks

- **FNAL** - D. Bauer, L. Hsu, P. Lukens, M. Hollister, N. Kurinsky, N. Mishra, D. Bowring, R. Khatiwada, D. Mitchell
- **NW** - E. Figueroa-Feliciano, Z. Hong, V. Novati, R. Ren, R. Chen
- **UMN** - N. Mast, G. Spahn, Z. Williams, M. Gardner
- **U. Florida** - T. Saab, C. Bathurst
- **U. Hamburg** - B. von Krosigk, A. Zaytsev, H. Meyer zu Theenhausen
- **SMU** - I. Saikia
- **UBC** - A. Li
- **CU Denver** - A. Roberts, B. Hines

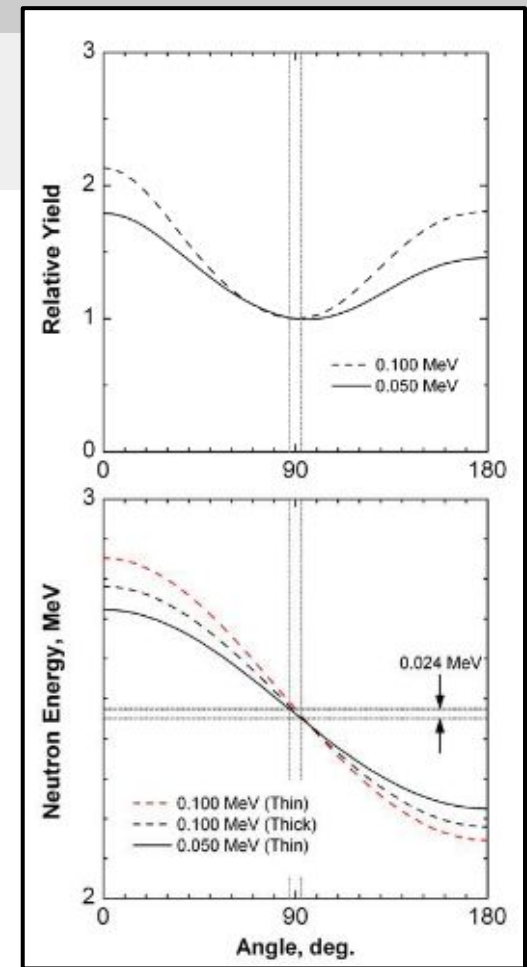
Thanks!



Backup Slides

DD Generator

- $D + D \rightarrow n + 3He$, $E_n = 2.45$ MeV
- 10^6 - 10^8 n/s in $\sim 4\pi$
 - Shape into “beam” with poly shielding
- Many can be pulsed at ~ 10 us
- Relatively compact



<https://www.doi.org/10.1063/1.3586154>

Abstract

The Northwestern EXperimental Underground Site at Fermilab (NEXUS@FNAL) is an underground cryogenic detector testing facility located in a clean room near the NOVA near detector. It currently features a vibration-isolated dry dilution refrigerator which operates down to 10 mK. The 300 meter water equivalent depth, combined with lead shielding around the refrigerator, is expected to lead to a background rate of <100 events/keV/kg/day. We present the current status of the NEXUS facility and overview of recent runs operating SuperCDMS R&D detectors. We also describe near and far term plans which include dark matter searches, qubit studies, neutrino detector development, and deployment of a neutron generator and backing array for neutron scattering experiments.